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ABSTRACT

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BUILDING A SUSTAINABLE WORLD: TECHNOLOGY, VALUES, AND SOCIAL CHOICES

Michael G. Wessels

Our planetary life support systems are at risk, and clean air, unpolluted water, and arable land are increasingly scarce. Environmental problems such as ozone depletion and the threat of global warming transcend national boundaries and confront our species with fundamental questions about our survival, our quality of life, and our responsibility to future generations. The purpose of this paper is to give an overview of the ecological crisis and to discuss the role of technology in the evolution, management, and correction of the crisis. It is suggested that what is needed to correct environmental problems is nothing less that a large scale transformation, including changes in institutions, norms, social practices, values, and lifestyles.

BUILDING A SUSTAINABLE WORLD: TECHNOLOGY, VALUES, AND SOCIAL CHOICES

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The early 1990s have been hailed as the gateway into a "new world order." The end of the Cold War reduced the immediate threat of global nuclear war, and the peoples of the world were presumably moving into an era of increased security.

Ironically, this is turning out to be an era of great *in*security. It is as if the world had awakened with a bad hangover from the Cold War, only to find that the environmental neglect of many years had created a deadly legacy of environmental damage and ecological distress. Reckless industrial practices in the Soviet Union put 70 million Soviets at risk of respiratory and other diseases from badly polluted air (Feshbach & Friendly, 1992). Similarly, the U. S. military buildup since World War II left a toxic time bomb that now threatens communities across the country (Shulman, 1992).

The ecological problems created in the U. S. and the former Soviet Union, however, are parts of a much larger problem of global environmental and social distress. Our planetary life support systems are at risk, and clean air, unpolluted water, and arable land are increasingly scarce. Environmental problems such as ozone depletion and the threat of global warming transcend national boundaries and confront our species with fundamental questions about our survival, our quality of life, and our responsibility to future generations. By themselves, environmental problems constitute a monumental challenge, possibly the greatest ever faced by humankind. They are particul-

arly difficult to correct because they are woven into the fabric of the social world, where they interact with and amplify social problems such as poverty, hunger, and economic decay, creating social systems that are in many cases marginally functional, suffused with suffering, and ripe for disintegration, chaos, and war.

Problems of such great magnitude naturally evoke fear, which in turn can invite a host of inappropriate psychological responses, not the least of which is denial (Postel, 1992). Despite powerful scientific evidence that environmental problems are already severe and are getting worse, some observers claim that no irreparable harm has been done and that the planet has essentially infinite capacity for renewal. Others engage in selective inattention, focusing on their careers or on economic problems while keeping environmental problems safely out of mind. Still others engage in scapegoating, blaming others for the problems while ignoring their own responsibility. A fourth psychological response is escape, either by moving to a presumably clean area or by adopting the NIMBY (not-in-my-back-yard) stance.

Whereas these reactions are incommensurate with the task ahead, it is possible to develop realistic, adaptive strategies for handling environmental problems. The first step is to become aware of the scope and the nature of the problems. The purpose of this paper is to give an overview of the ecological crisis and to outline the pivotal role of technology in the evolution, management, and correction of the crisis. I shall analyze technology as neither villain nor savior but rather as an integral part of a broader social system permeated by values of individualism, materialism, growth, and consumption. In addition, I will suggest that what is needed to correct environmental problems is nothing less than a large scale social transformation, including changes in institutions, norms, social practices, values, and lifestyles. The central theme is that to overcome the crisis, humankind must shift from a social system based on values of domination to one based on values of sustainability.

The Environmental Crisis

My overview of the environmental crisis will of necessity be brief and selective, and it will focus on six main problems.

1. Thinning of the Atmospheric Ozone Layer. One of the best documented and widely appreciated environmental threats is the depletion of stratospheric ozone, which provides a protective shield against the penetration of harmful ultraviolet radiation, a known source of skin cancer. Research in the 1970s (e. g., Molina & Rowland, 1974) had shown that chemical compounds called chloroflourocarbons (CFCs) were broken down by ultraviolet radiation into chlorine and oxygen in the stratosphere, where every chlorine atom can act as a catalyst for the destruction of many thousands of ozone molecules. This situation was distressing since CFCs were used widely in refrigerators, automobile air conditioners, aerosol sprays such as deodorants, building insulation, and even in the production of styrofoam cups. But it was not until the mid-1980s that research had documented the presence of a hole in the ozone layer over Antarctica, where ozone concentrations had plummeted by 95%, and had determined that the primary culprits were CFCs and halons (bromine containing fluorocarbons) spreading throughout the stratosphere (Gushee, 1992).

Currently, uncertainty exists in regard to how extensive the depletion of the ozone layer is, and there are regional variations in the amount of ozone thinning. Yet many estimates place overall losses at somewhere between 2% and 5% (Gushee, 1992; Sivard, 1991), and there is agreement that ozone depletion will increase risks of skin cancer. In Queensland, Australia, 75% of people over 65 years of age now have some form of skin cancer. A reduction of ten percent in the ozone layer could result in 160,000 additional cases of nonmelanoma skin cancer in the U. S., and the Environmental Protection Agency has estimated that it would also produce approximately four million cases of cataracts, which lead to visual impairment and blindness (Ehrlich & Ehrlich, 1991). In addition, the increased penetration of ultraviolet radiation could suppress the human immune system, which is already under strong assault by the AIDS virus. In the nonhuman realm, increased penetration of ultraviolet radiation can damage many plants, including agricultural crops and also marine phytoplankton communities, which are crucial links in oceanic food chains. What makes this situation most disturbing is the long-term nature of the threat – even if CFC and halon emissions stopped completely today, stratospheric ozone destruction would continue for decades since compounds now in the trophosphere would continue to diffuse into the stratosphere (Graedel & Crutzen, 1989). This is a powerful example that environmental damage done today can threaten the lives and well being of many future generations. It also illuminates the truly

global nature of the problems: since CFCs do not respect national boundaries, irresponsible use of this technology anywhere can threaten people everywhere.

2. *The Nuclear Legacy*. Nuclear technology is undoubtedly among the most powerful technologies developed by humanity, yet its effects have been far from uniformly positive. During the Cold War, fearful superpowers raced to build nuclear weapons in order to deter attacks by the other, but behind the scenes, the biggest bomb of all was being created – an environmental bomb seldom discussed publicly. Between 1944 and 1947, the Hanford Nuclear Reservation in Washington state, where the material for the Manhattan Project's atomic bomb was manufactured, released approximately 400,000 curies of radioactive iodine-131 into the atmosphere, exposing 10,000 residents to very dangerous levels of radiation (Shulman, 1992). This disaster dwarfed that of the Three Mile Island nuclear accident, which released less than thirty curies, and it was deliberately kept secret by both Hanford officials and Department of Energy officials (Shulman, 1992). Similar disasters poisoned the Soviet Union, where the plutonium production facility called Chelyabinsk-40 dumped 120 million curies of the radionuclides cesium 137 and strontium 90 into Lake Karachay near the southern Urals. Wind has dispersed the radioactivity from the lake, contaminating a surrounding area of 1,800 square kilometers. Today the Lake is one of the most poisonous places on earth, and a person standing on its shore would receive a lethal dose of radiation in approximately one hour (Cochran & Norris, 1991). Unfortunately, these nuclear weapons disasters were sent abroad, if not by proliferation then by nuclear testing. For example, nuclear testing by the U. S. and France in the Pacific produced extensive coral damage, increasing the production of ciguatera toxins that have poisoned the dominant food supply – fish (Ruff, 1990).

Now the U. S. and other nuclear powers face the immense problem of managing and disposing of nuclear waste, a problem that will only grow as nuclear proliferation continues. The aging U. S. weapons complex, for example, has produced large amounts of plutonium, which remains radioactive at dangerous levels for 240,000 years. Even very small amounts of plutonium can cause lung, bone, or liver cancer. At the Rocky Flats nuclear facility, which is used to produce and to retire plutonium warhead components, there are approximately 9,000 kilograms of "lower level" plutonium scrap on the premises (Albright, Zamora, & Lewis, 1990). No accept-

able plan exists for disposing of this waste, despite suggestions ranging from burial in deep mines to launching it into outer space, and it is estimated that the costs of cleaning up the nuclear weapons complex will run into the hundreds of billions of dollars (Lenssen, 1992; Shulman, 1992). This is but one illustration of the intimate connection between economic and environmental issues.

3. Pollution. Problems of land, air, and water pollution are increasing globally, and air pollution has become a major health hazard in cities around the world. Among the most serious problems is acid deposition stemming from heightened atmospheric levels of sulfur and nitrogen oxides from the burning of fossil fuels and of forests and grasslands. In the atmosphere, these oxides are transformed into sulfuric and nitric acids, creating "acid rain" which can acidify pH-sensitive soils and lakes hundreds of miles downwind from the sites of the oxide production (Ehrlich & Ehrlich, 1991). Acidification has led to fishless lakes in parts of North America, Britain, and Scandinavia, and it has also contributed to forest declines in Europe, which suffered some $30 billion in acid-induced losses of wood in 1990 alone (Ehrlich & Ehrlich, 1991). The global dimensions of water pollution problems have become apparent in large oil spills such as the 1989 spill of the Exxon Valdez, which emptied 11 million gallons of oil off the Alaskan coast, coating 4,000 miles of shoreline (Ehrlich & Ehrlich, 1991). Problems of water pollution became apparent in many communities such as those in Ohio along the Cuyahoga River, which periodically erupted into flames!

The U. S. faces very serious waste problems, as the amount of solid waste produced between 1960 and 1986 shot up by 80% while the population grew by 34% (Office of Technology Assessment, 1989). Although the public has become familiar with toxic time-bombs such as that which devastated the community of Love Canal in New York State, less attention has been paid to the thousands of toxic sites created by the U. S. military (Shulman, 1992). The Pentagon generates nearly 500,000 tons of toxic waste annually, yet it has not been required to meet high standards of environmental and health protection.

Increasingly, the waste stream includes so-called "low-level" radioactive wastes that pose significant health risks (Saleska, 1990). Large amounts of radioactive waste come from commercial nuclear reactors. The irradiated fuel now produced and housed in the U. S. has a radioactivity of over 20 billion curies. Most of it is stored in large pools of cooling water near aging

nuclear reactors, and both scientists and the public have strong fears that leakage could contaminate public water supplies. As in the case of plutonium waste, safe long-term disposal remains a very serious but unsolved problem (Lenssen, 1992). Aside from the problems of waste disposal and management, the risks associated with nuclear power were brought home by the Chernobyl nuclear accident in 1986, which released 50 million curies and which could lead to tens of thousands of cancer deaths (Lenssen, 1992).

4. Global Warming. Scientists also have growing concerns that industrial civilization may be changing the earth's climate by warming the globe through a mechanism similar to that at work in greenhouses. In this "greenhouse effect," gases in the atmosphere such as carbon dioxide and methane "absorb infrared radiation from the sun-warmed surface of the planet and then return the radiation to the earth" (Graedel & Crutzen, 1989, p. 58), thereby warming the planet. Since the beginning of the Industrial Revolution, the atmospheric concentration of carbon dioxide has increased by 26%, and it continues to rise (Postel, 1992). Industrial civilization now adds approximately six billion tons of carbon in the form of carbon dioxide to the atmosphere through the burning of fossil fuels such as oil, coal, and natural gas (Ehrlich & Ehrlich, 1991). Large amounts of CO2 are also released by biomass burning, as occurs in the slash-and-burn agriculture prevalent in many parts of the Third World. In addition, atmospheric concentrations of methane are increasing due to factors such as cattle herds, expanded rice farming, and garbage dumps (Ehrlich & Ehrlich, 1991).

The impact on civilization of relatively small temperature changes is shown by the fact that during the last Ice Age, the temperature of the planet was only nine degrees (F) less than today (Ehrlich & Ehrlich, 1991). Many scientists fear that a warming of even several degrees could weaken the productivity of the world's breadbaskets, increasing hunger and starvation. Global warming could also cause rising sea-levels via the melting of glaciers and the expansion of warming water (Ehrlich & Ehrlich, 1991). Rising sea levels would increase coastal erosion, flooding, and storm damage; increase the salination of coastal aquifers; and threaten the homes of large numbers of people, who are disproportionately concentrated in coastal regions. But the most far-reaching effects could come through a spiral of habitat change, species extinctions, and ecosystem disruptions. Ecological communities are systems in which there is a high degree of interdependence, and changes in several elements of a community can have ripple effects that spread far

beyond the initial points of impact.

Because changes of even a few degrees can be highly significant for many species, the possibility of global warming demands urgent attention. Unfortunately, relatively little is known about global warming, and there is much debate about how much warming may occur and what its consequences will be (cf. Lanouette, 1990a, 1990b; Leggett, 1992; Singer, 1992). The potentially tragic irony here is that delays in addressing the problem may allow irreparable damage. Following ecologists such as Paul Ehrlich, one might well question the wisdom of playing "environmental roulette." (1968, p. 61)

5. *Deforestation.* The increase in greenhouse gases is facilitated by the destruction of forests, which have the capacity to remove large amounts of carbon dioxide from the atmosphere. Each year, approximately 17 million hectares of forest, an area roughly the size of Austria, are destroyed (Brown, 1991). In 1989 alone, 55 thousand square miles of tropical forest were destroyed (Ehrlich & Ehrlich, 1991). This is particularly troublesome since tropical forests are the home of many thousands of plant and animal species that have never been studied or appreciated. Whereas approximately 1.4 million species have been identified, the number of extant species is believed to be very much higher – somewhere between 10 million and 80 million (Ryan, 1992). In addition to being sources of beauty and wonder, these species are the repository of tremendous amounts of genetic diversity, and they exist in an interdependent system in which the loss of one can influence many others. The extinction of these species means not only lost companions in the ecological community but also utilitarian losses for people, as intricate food chains are disrupted and as many useful drugs and agriculturally useful plants are lost (Myers, 1979). The potential scale of extinctions has been suggested by noted biologist E.O. Wilson, who estimates that the destruction of tropical rain forests leads to the extinction of 50,000 invertebrate species each year (cited in Ryan, 1992, p. 9).

Much of the assault on forests comes from displaced farmers, from unsustainable logging and agricultural practices, and the effects of pollution. But it also comes from intensified pressures on fuelwood, the main energy resource for half the people in the world (Ehrlich & Ehrlich, 1991). In developing nations such as India, the firewood shortage has stimulated excessive felling and cutting of trees. The stripping of tree cover leaves the land more vulnerable to erosion, flooding, and desertification. In turn, the expansion of deserts alters local climates, reduces agricultural yields, and in-

creases the poverty and hunger that already racks the Third World.

6. *Resource Depletion.* Beyond forests, many natural resources are being mismanaged, increasing conditions of scarcity. A well known case is the Aral Sea, which in 1960 covered 26,000 square miles and was the second largest lake in Asia. Excessive diversion and irrigation have led to the extinction of 24 native fish species and left 11,000 square miles of the lake parched and sprinkled with stranded fishing boats that had once been part of a thriving Soviet fishing industry in the area. Now large salt storms blow some 40 million tons of salted dust north each year, where salinization will threaten valuable croplands (Ehrlich & Ehrlich, 1991). In addition, water shortage is a chronic problem in many countries such as Israel. Indeed, heightened competition for control over the water of the Jordan River is a powerful source of tension in the conflict-ridden Middle East, providing a grim reminder that increasing resource scarcity is a likely trigger for future wars.

Worldwide, soil erosion and depletion is a major problem, increasing both desertification and agricultural losses. Since the first Earth Day in 1970, some 480 billion tons of topsoil – the equivalent of India's farmland – have been stripped away by erosion (Brown, 1991). Significant losses have also occurred in wetlands, which serve as natural reservoirs, reduce flooding, and support a diversity of wildlife. It is estimated that the continental U. S. has already lost nearly half of its original wetlands (Steinhart, 1990).

Each of these problems is dangerous and is clearly global in scope. But the full severity of the threat to the environment becomes apparent only when one realizes the interactive, synergistic nature of these problems and the positive feedback mechanisms that amplify them. As one example, air pollution and excessive burning of fossil fuels contribute to global warming, which can increase deforestation. In turn, deforestation can increase global warming and stimulate erosion and desertification, which can alter local climates and produce further deforestation and ultimately, more warming. Since these problems are interconnected and systemic, they will resist fragmented, piecemeal conceptualizations and correctives. No small part of the task in addressing these problems is to develop modes of holistic thinking that are geared to finding systemic solutions.

The magnitude of the environmental threat also becomes apparent in light of the growth of the world population, which now stands at approximately 5.3 billion (Sivard, 1991). Furthermore, the global population is growing

annually at a rate equivalent to adding another Mexico every year (Postel, 1992), and it is expected to increase by another 960 million people in the 1990s (Brown, 1991). If the death rates stay low, the global population could swell to 11 billion people within several decades (Ehrlich & Ehrlich, 1991). This population explosion will not only swell the ranks of the hungry and the poor but will also amplify all of the problems discussed earlier, intensifying the pace of environmental degradation.

To be sure, there is nothing new about environmental degradation, which has played a major role in previous eras and altered the course of entire societies. What are new are three factors: the truly global scope of the problems, the unprecedented magnitude of environmental damage, and the possibility of inflicting irreparable damage on a vast scale. In previous eras, human activities did not threaten the planet's ozone layer, nor did they alter the global climate. The current environmental threat cuts across national boundaries, reigning ideologies, and stages of technological development – environmental degradation threatens all nations, rich or poor, capitalist or socialist, technologically advanced or preindustrial. At risk is the global environmental commons upon which all people depend, giving new urgency to the words of Chief Seattle's Message: "Whatever befalls the earth befalls the sons of the earth. Man does not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself." (Seed et al., 1988, p. 71.) At the very least, the environmental crisis ought to trigger reflection upon our prospects for survival, our responsibility to future generations and to other species, and the spiritual and moral condition of humankind.

Technology and Social Systems

To understand and respond effectively to the environmental crisis, it is essential to think carefully about the role of technology, which has amplified the human impact on the environment and which has contributed significantly to global problems such as ozone depletion. The analysis of technology's role is impeded by several simplistic notions about and impassioned reactions toward technology, which some regard as a religion and others regard as a scourge. To discern the roots of the problem, it is useful to examine briefly three prominent views of technology and its relation to the environment. The first two of these are myths, yet both have attracted large followings.

The Technical Fix. Technological optimists have championed the myth of the technical fix. It is tempting to think there might be a technological solution for environmental problems since historically, technology has corrected some seemingly insurmountable problems. Two centuries ago, prophets of doom such as Thomas Malthus predicted that hunger and starvation would limit human population growth. But breakthroughs in agricultural technology have enabled increases in food production to surpass increases in population, overcoming the Malthusian dilemma (Ehrlich & Ehrlich, 1991). Furthermore, the broader sweep of human evolution reveals a close and enduring relationship between people and technology. The fossil record indicates that the manufacture and use of tools played an important role in human evolution and was inextricably intertwined with the enlargement of the human brain, which enabled our remarkable capacities for imagination, creativity, and problemsolving (Campbell, 1982). This close evolutionary partnership invites the idea that as in both the ancestral past and in the more recent chapters of recorded history, technology will somehow enable humankind to overcome its problems.

Although the technical fix mentality offers comfort and hope, it amounts to wishful thinking. One of the hard realities we must face is that irreversible damage may be done before corrective technologies are developed. For example, technologies for correcting the damage to the ozone layer may be developed in the future (numerous technical solutions have already been proposed). But significant damage is being done today, and the chain reactions that result may cause problems far into the future, even after the stratosphere had been cleaned up. What makes this situation even more dangerous is the limited understanding we have in regard to environmental problems. Finding a technical solution presumes a rather thorough understanding of the problem, and it is entirely possible that environmental problems will reach unmanageable proportions before this understanding has been achieved.

To assume that technical solutions will somehow be found is an act of hubris or excessive pride, a sin that tempts all who would play god using technology. We ought to be humbled by remembering that what appear to be promising, clean technologies can turn out to be profoundly dangerous. Indeed, CFCs were hailed in the 1930s as "the perfect invention for the age of technology." Moreover, the automobile, one of the worst polluting devices ever created, was viewed by New Yorkers in the early part of this century as the answer to the pollution of city streets by horses (Hickman & al-Hibri, 1981). In many cases, presumed technological fixes turn out to be at least as

bad as the problems they had been intended to remedy.

On a deeper level, technology alone cannot correct the environmental crisis, which is far more than a technical problem. For example, a useful technical step in addressing ozone depletion is to produce harmless chemical substitutes for CFCs and halons, as has already occurred. But what happens if some CFC-producing nations find it more economical or technologically simpler to continue using CFCs and halons? Furthermore, how can the U. S. expect developing nations to refrain from using the technologies that Americans have long enjoyed? Is it fair or realistic for the U. S., which for decades produced vast amounts of CFCs and halons to suddenly demand that developing nations such as China, which has an ambitious program to make refrigerators available to its citizens, avoid the use of CFCs and halons? Thus what looks like a technical issue – how much ozone-depleting material will be produced – turns out to be a nexus of difficult political, economic, psychological, and ethical issues. Accordingly, it is unreasonable to expect a technical solution to the environmental crisis.

Technology is the Problem. The converse myth is that technology is the primary cause of the environmental crisis. This myth contains a germ of truth since technology has figured prominently in the degradation of the environment. Problems such as toxic wastes, the production of greenhouse gases, ozone-depleting materials, and high-impact lifestyles all owe significantly to the use of technology.

This myth gains added strength from the transforming impact that technology has had on civilization. As Lewis Mumford (1963) pointed out, the mechanical clock, a thirteenth century invention, became a defining feature of urban existence and enabled the standardization, timing, and transportation that contributed to the rise of the industrial era. Similarly, the steam engine contributed mightily to the Industrial Revolution that transformed civilization and created ever increasing levels of dependence on technology. Living in the current era of high technology and information, computers have a powerful impact on how people live, work, and play (Wessells, 1990). In light of these patterns, it is tempting to single out technology as the primary mover of civilization and the source of its ills.

Unfortunately, this view overlooks the fact that it is people who create and apply technology – people have choices about whether to develop particular technologies and how to apply them. That technology is not autonomous is shown by the ability of societies to form agreements such as the Montreal

Protocol that limits the use of ozone-depleting chemicals. Since humans create technology and choose whether to develop and use it, people must ultimately shoulder the blame for the environmental crisis. In this sense, the environmental crisis is really a crisis of civilization, and the human factor deserves at least as much attention as the technological factor.

In addition, technology is not monolithic. Indeed, many technologies are environmentally benign and will probably play a significant part in responding effectively to the environmental crisis. Solar energy, clean-burning fuels, halon substitutes, and methods of sustainable forestry and agriculture are among the many technologies that are very useful but that have relatively low levels of environmental impact. Although technology is part of the problem, it may also provide part of the solution. Despite the simplicity and the emotional release offered by technology-bashing, this dichotomous thinking neither illuminates the roots of the current environmental problems nor suggests how to address them.

Technology as a Reflection of Values. A richer view is that technology is an integral part of a social order that embodies particular values that inform and shape social institutions, practices, modes of production and organization, and patterns of living (cf. Pacey, 1983). From this systemic perspective, technology is neither the primary cause of nor the cure for environmental ills. As an example, consider one of the most cherished forms of American technology – the automobile. Automobiles reflect the values placed by Americans on mobility, freedom, convenience, comfort, and material gain. Both a product of and a stimulus for wealth, the American automobile industry is an economic giant that directly or indirectly creates jobs for millions of citizens, and threats to the industry by unfair foreign competition or by environmental extremists are taken very seriously by American politicians. The fate of the automotive industry is inextricably linked to that of related steel, chemical, and petroleum industries. Behind the development of new automobiles are profithungry corporations that draw on the talents of large cadres of scientists and engineers, who in turn are trained and supported by a vast educational infrastructure. Automobiles are part of the American lifestyle, as millions of Americans drive to work each day, one person per car, from comfortable homes in the suburbs. The suburban exodus, coupled with the insatiable appetite for more cars and easier travel, has led to the creation of a sprawling infrastructure of roads and highway departments. The American love affair with the automobile has also led to

the creation of a mammoth system of insurance companies, loan agencies, lawyers, police officers, automobile dealers, gas stations, and repair shops.

This systems perspective, which applies to many different technologies, suggests that what appear to be environmental problems or technology problems are in fact social problems concerning values and socially constructed institutions, norms, and practices. Strong values on individual freedom, comfort, and mobility create the impetus for the automotive industry, which is buttressed by powerful economic and political values. These values permeate the U. S. and encourage lifestyles that are personally convenient but environmentally destructive.

In addition, this systems perspective clarifies why it is so difficult to correct environmental problems. Since the problems have systemic origins, they cannot be remedied through bandaid approaches or piecemeal solutions. To reduce reliance on the automobile in the U. S. would require not only large changes in lifestyles but also in transportation infrastructure, in industry, and in supporting service sectors of the economy. Furthermore, proposed changes bring into play the conflicting values and political currents that lay under the surface of every society. For example, a proposal for a law requiring that automobiles get at least 40 miles per gallon entails significant tradeoffs between environmental and health values on one hand and economic and convenience values on the other. Meeting the regulations may be possible for automobile manufacturers and dealers, but only after significant research and redesign, which will raise significantly the prices on their products. These higher prices may reduce consumption and industry growth, which can in turn harm the U. S. economy and American competitiveness. The questions then become what are the costs and benefits of the proposal, who stands to benefit most, and how is the decision to be made. Thus, what appear to be straightforward issues about environmental quality turn out to be vexing issues of values and value-tradeoffs that get played out in a kaleidoscopic, rapidly-changing political arena, where current public concerns and diverging ideologies, organizations, political groups, policy makers, and governmental processes have a profound influence.

From this standpoint, human values lie at the heart of the environmental crisis. Although this is true worldwide, the problem is best illustrated in industrialized societies such as the U. S. The problem in industrialized societies is not the use of technology per se but rather the use of technology in accord with values and modes of production and organization that are unsustainable and that produce excessive environmental damage. In Western in-

dustrialized nations, many of the main values concern domination and control over nature. These values ran strong in medieval Europe, where they were part of an anthropocentric world view in which people are the pinnacle of the natural universe and are set apart from the rest of Nature (Sale, 1990). Even outstanding scientists such as Francis Bacon spoke of "that right over Nature which belongs to [humans] by divine bequest" (cited in Sale, 1990, p. 81). The voyages of Columbus carried these values to North America, where exploration and exploitation went hand in hand and where colonizing values of subjugation helped to structure the social order. Several centuries later, the rise of a capitalist order, coupled with the Industrial Revolution, expanded global markets, whetted appetites for greater profits, and created powerful new sources of wealth. Strong ties were forged between technology, capital investment, mass production, and wealth, establishing a pattern that persists today.

A defining feature of contemporary Western society is the use of technology to dominate the natural world and to achieve wealth. Increasingly powerful technologies have enabled Western societies to make use of vast natural resources, to unleash the power of the atom, to double longevity, and to explore space. In the West, success is defined largely in terms of individual wealth and material acquisition, and the ownership of multiple automobiles, an air-conditioned home, a television, a VCR, and a microwave oven have become utterly commonplace. The economic order is built around a free-market system in which the quest for profit and wealth plays a primary role and in which economic health is defined in terms of growth and productivity. Individual freedom is a core value of the system, which thrives on the interplay between individual creativity and entrepreneurship, particularly in regard to the imaginative use of technology. Throughout the Western world, progress is defined in terms of technological development, the rise of democracy and individual freedoms, and increases in growth and the material standard of living.

These values have created a situation in which there are few restraints on technology. If a new technology has consumer appeal, profit incentives drive forward its development, marketing, and distribution. If the new technology increases convenience and comfort or constitutes a coveted status symbol, then it becomes something everyone "has to have," and acquisition of it becomes normative. With each acquisition, one becomes more accustomed to living with technology and to having higher levels of comfort and convenience, creating an upward spiral of more technology and more conveni-

ences. In the corporate sector, technology advances in areas such as robotic mining, information management, and artificial intelligence are driven forward by ever increasing demands for efficiency, competitiveness, and higher profit margins. In this manner, technology has become woven into the fabric of individual lifestyles and corporate activities in a system that nourishes growth and high levels of consumption. But the combination of affluence and technology carries a steep environmental price, as the average American has approximately fifty times the environmental impact of someone living in Bangladesh and several times as much impact as someone from Japan, the United Kingdom, Sweden, or France (Ehrlich & Ehrlich, 1991).

No one can dispute that this system has produced dramatic improvements in the material standard of living over the past few centuries. The system, however, is geared more towards high consumption than towards environmental protection. Since the present system places relatively little value on environmental preservation, the forces of growth, wealth, and consumption surge ahead, while environmental protection remains something of an afterthought, a reactive adjustment made once a significant problem arises. If the problems were relatively small or if the global population were stable, this reactive mode would be appropriate and would allow a business-as-usual approach. But the difficult lesson which humankind must now learn is that spaceship earth is at risk, and the economic and social well being of future generations are threatened. Furthermore, the problems are systemic and cannot be fixed through bandaid solutions or isolated cleanups of toxic waste sites. We must change our values, our lifestyles, our modes of production and living.

Toward a Paradigm of Sustainability

What is needed is a paradigm shift – a shift of values, social practices, and world view. The new paradigm should be centered around the idea of sustainability, defined following the Brundtland report (1987; see also Milbrath, 1989; Ehrlich & Ehrlich, 1991; Gore, 1992) as living within the limits set by the environment and meeting present needs without compromising the ability of future generations to meet their needs. A sustainability paradigm would not, as is sometimes thought, devalue economic prosperity and technology. Instead, it would unite economic health with ecological health, reframe ideas about progress, reconceptualize the relationship between people and nature,

and guide the development of environmentally benign technology.

Sustainability Values. At the heart of the sustainability paradigm is a set of values that are oriented toward the long-term well being of our species and our planet. Whereas the central values of the current industrial paradigm are domination, material wealth, and growth, the central values of a sustainability paradigm are environmental preservation, interconnectedness, and limits to growth. The sustainability paradigm would create a new social consciousness that recognizes the interconnections between long-term economic health and ecological viability, between present generations and future generations, and between humans and Nature. This sense of interconnectedness provides a bridge between people and Nature, healing the wounds of separation and alienation from the natural world that are part of the affliction of the contemporary civilization (Lifton, 1992; Mack, 1992).

In this new social consciousness, a high value would be attached to environmental preservation, recognizing that one of our greatest social responsibilities as parents and as citizens is to pass on a bountiful world to future generations. As Lester Milbrath has put it, "Life in a viable ecosystem is the core value of a sustainable society... Ecosystems function splendidly without humans but human society would die without a viable ecosystem." (1992, p. 4.) In the current industrial paradigm, environmental problems are often regarded as the necessary price of progress or are relegated to the back burner until they reach crisis proportions. By contrast, preservation values bring environmental issues to center stage, encouraging proactive efforts to protect the global environmental commons and creating a critical awareness that damage done to the environment is damage done to ourselves, to our children, and to their children, and so on. A sustainability paradigm would have a strong emphasis on prevention, challenging every citizen, every industry, and every nation to reflect with vigor and foresight on the environmental implications of its proposed activities and policies.

Whereas the industrial paradigm encouraged unlimited growth, a sustainability paradigm emphasizes living within the limits imposed by ecology, social organization, and current technology. Sustainability does not mean no growth; it means responsible growth that does not jeopardize planetary life support systems and that does not privilege the well being of current generations over that of future generations. In turn, limited growth entails individual sacrifice, particularly in technologically advanced societies, where the average person uses over eighty times as much energy as a person in

sub-Sahara Africa (Brundtland et al., 1987). On a very fundamental level, the primary emphasis must shift from what is convenient and comfortable for the individual to the collective good. The collective good must be defined broadly, not only in terms of this generation but of future generations as well. Recognizing the ecological interconnectedness of different species, the collective good should also include the well being of other species.

Adopting these values would entail a profound shift in our world view and patterns of living. Instead of viewing people strictly in the dominating role, we would think of humans as powerful members of a complex ecological web shared with many other species. In short, this paradigm views humans as part of Nature but not as its center. This paradigm also challenges current concepts of development and progress, which too often are defined solely in terms of material wealth, technological sophistication, and growth of the GNP. The core idea of the sustainability paradigm is that short-term industrial and material gains cannot be justified if they come at the expense of excessive environmental damage, the true costs of which seldom enter into traditional economic analyses. The paradigm calls for softer, gentler lifestyles, environmentally responsible patterns of production and consumption, and policies that make a sustainable system work.

Having outlined what the sustainability paradigm is, it is appropriate to say a few words about what it is not. First, it is not an extremist assault that would undermine all Western values and pull the plug on industry. The sustainability paradigm does not place the well being of each nonhuman species above that of humans. It recognizes that there are difficult tradeoffs that must be made between economic and ecological concerns. What is does encourage is responsible industry, growth within reasonable limits, and an acceptance of wealth as only one dimension of the quality of life. Second, it does not entail technology-bashing and rejection but rather the development and use of environmentally appropriate technology.

Third, it is not a blueprint. This is appropriate insofar as there may be diverse paths toward sustainability, and it is highly likely that some of these have not been envisioned yet. Moreover, sustainability is a moving target since the influx of new scientific information can rapidly change assessments of our environmental predicament and lead to the discovery of unforeseen problems or of partial solutions to them. The ability to tolerate this ambiguity and this incompleteness of information is no small part of meeting the challenge of the environmental crisis. Furthermore, there are no widely accepted benchmarks for judging what counts as sustainable practice. For

example, who decides what is sustainable and how far ahead we should be looking? In the Iroquois nation, tribal councils were charged with considering the impact of decisions seven generations into the future (Gore, 1992). Although this system was based upon intergenerational ethics, a much larger ethical and planning horizon needs to be used in dealing with very long-lived toxic wastes and the much greater time spans involved in evolution. Viewed with humility, our situation demands that we admit that we have much to learn about building a sustainable world. From this standpoint, humankind is involved in a process of discovery and co-evolution with the natural world, and continuing reflection and dialogue are crucial for the success of this process.

Steps Toward Sustainability. Despite these uncertainties, there are a number of choices that can be made to begin moving in the direction of sustainability. Although environmental cleanup and restoration are important, a more fundamental step is to *prevent* environmental damage by reducing consumption and impact. One obvious means of doing this is to preserve scarce resources such as rainforests, wetlands, clean water, and topsoil. Another important method is to reduce sharply the consumption of fossil fuels, one of the main causes of air pollution, acidification, and heightened atmospheric levels of greenhouse gases. Many means of reducing the burning of oil and coal are well known and ready for deployment – increased development and accessibility of renewable energy sources such as solar energy; the imposition of gasoline taxes and feebates that give automobile purchasers rebates that are proportionate to the fuel efficiency of their cars; improvements in the mass transit systems that have enabled reduced driving in Europe; stricter environmental regulation of the military, which has produced an inordinate number of toxic waste sites and which uses in one year an amount of energy sufficient to run the U. S. mass transit system for nearly 14 years (Renner, 1991); higher government standards for cleaner air; and incentives for home and industrial energy conservation, among many others.

A second step is to develop additional technology that allows both sustainability and profitability. Fortunately, this type of technology is increasingly available. For example, compact florescent lamps now cost approximately $15 but yield an energy savings in the amount of nearly $50 in the life of the average lamp. In Massachusetts, Taunton Municipal Lighting now leases these compact florescent bulbs to customers for 20 cents a month,

generating significant savings for the customers and acceptable profits for the company (Ehrlich & Ehrlich, 1991). In the long run, there is great promise for clean technologies that increase agricultural yields, decrease reliance upon chemical pesticides and ditch irrigation, convert municipal waste into useable energy, reduce the flow of polluting materials into the environment, and produce new sources of renewable energy. The sustainability paradigm nurtures technological progress, but it broadens the definition of "progress" to include ecologically sensitive values and responsibility to future generations.

A third step is to redefine security, which during the Cold War was conceptualized in terms of the ability to thwart and deter a military attack. Military dimensions of security remain very important, but there is now a need to ask how secure a society really is if it pollutes its own house and damages the ecological foundation that underlies its long-term economic strength. As shown all too vividly by the problems of the U. S. and the former Soviet Union, environmental degradation, economic decline, and social disintegration are thoroughly interwoven and exceed the boundaries of military concepts of security. What are needed now are holistic approaches to security that embody these interconnections and that bring environmental, economic, and social justice issues into the center of the security dialogue.

The fourth step is to create sustainable development policies at many different levels, from the local to the global. Behind these policies should be sustainability plans that identify creative ways of achieving both economic vitality and environmental quality. These collectively defined plans should set appropriate targets for clean air and water, for waste management and disposal, for acceptable agricultural and industrial practices, for developing and using clean technologies while phasing out older, less efficient technologies, etc. A central part of these plans would consist of job creation programs designed to facilitate economic conversion away from the most damaging forms of industrial and military production. For example, municipal governments might offer tax incentives for relatively clean industries such as the solar power industry, which is highly labor intensive and a potentially rich source of employment for the community. In creating sustainability plans, groups should use full cycle accounting that includes in the prices of products the hidden costs of dealing with environmental damage from the production process or of cleaning up pollution from the use of the product. Thus, achieving sustainability requires not only "green" policies and activities but also a fundamental change in our views of economics.

In the international arena, sustainable development requires the responsible use of technology worldwide. Too often, development programs have equated progress with the use of more technology, even if it produced severe environmental damage and human catastrophe, as in the Bhopal disaster. Moreover, there has been a tendency to look to technology for a quick agricultural or economic boost, and this approach has often backfired. For example, in Sikandernagar, tractors were introduced in hopes of increasing agricultural yields, but tractors soon replaced human labor, reducing jobs and wages in a spiral that actually increased poverty (Jacobson, 1992). Fostering sustainable development will require significant increases in international awareness, in sensitivity to the needs, dynamics, and values of different cultures, and in willingness to help impoverished nations. It will be essential to provide economic assistance for environmentally responsible programs in Third World countries that are strapped by grinding poverty, huge debts, and burgeoning populations and that cannot reasonably be expected to put environmental preservation high on the agenda while the masses are starving.

The encouragement of sustainable development also requires systemic, holistic thinking that makes the connections between environmental degradation and problems such as militarism and sexism. Nations such as Syria that spend nearly forty percent of their GNP on the military cannot hope to devote appropriate amounts of resources to environmental preservation, not to mention health care and other social services. Similarly, programs aimed at reversing deforestation in Africa have faltered because the program planners failed to consult the village women who are the main foresters and collectors of fuelwood (Jacobson, 1992). Fragmented, compartmentalized thinking that views development as a process of wealth creation or of technological advancement is doomed to failure. At every level, systemic connections need to be made between environmental issues and issues of social justice, poverty, militarism, and overpopulation.

Because environmental problems are global in scope, they demand global solutions. Although the world is carved up rather arbitrarily into independent nation-states and is witnessing a resurgence of virulent nationalism, there is a pressing need for international cooperation on addressing global environmental problems. Already, significant international cooperation has occurred through the United Nations Environmental Program and through the establishment of agreements such as the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, which called for a freeze on con-

sumption levels of CFCs followed by 50% reductions by 1999 and which has now been signed by over 75 nations. The Montreal Protocol was subsequently modified in the London Accord, which calls for 20% cuts in CFC consumption by 1993 and for a total ban on CFCs and halons by the year 2000 (Gushee, 1992). Moreover, the recent occurrence of the Earth Summit was a landmark that signaled not only global consciousness of environmental problems but also increased international willingness to collaborate broadly in dealing with these problems. Although many leaders were profoundly disturbed by the failure of the U. S. to support the Biodiversity Treaty and by the general lack of leadership by the U. S., the Earth Summit points governments in the direction of increased environmental awareness and responsibility. Of course, governments are a large part of the problem, and this realization has spawned grass roots environmentalist groups and populist Green politics in many different countries. International environmental groups such as Greenpeace have undergone stunning growth and increases in activity and public visibility. These nongovernmental organizations help to build a sense of global citizenship, and they add new meaning to the adage that even when governments and leaders are blind, the people will lead.

One of the key steps in building global awareness and citizenship is effective development education, which complements projects such as international education. Development education is essential if we are to learn to be global citizens, to appreciate our interconnectedness with other living things, and to think systemically and holistically. In developing nations, educational efforts are particularly needed in addressing the problem of overpopulation. Most of the world's population growth is occurring in relatively impoverished nations where the span of effective childbearing years is not shortened by education, where people rely on large families rather than education for economic support, and where the linkage between large family size and poverty is not widely understood. Although the U. S. population size is relatively stable, overpopulation is also a U. S. problem, for the average American produces an extraordinarily large environmental impact. Policy makers also need ongoing development education, which ought to encourage critical thinking about development processes, increase sensitivity to different cultural values and patterns of living, and weaken the grip of ethnocentrism.

The environmental crisis demands a systemic shift in world view as great as that triggered by Copernicus and a social transformation every bit as monumental as the agricultural and industrial revolutions. The immensity of

this task can often leave one feeling hopeless and overwhelmed. But we should find hope in the fact that a mere decade ago, virtually no one thought it was even remotely possible to end the Cold War, just as one hundred fifty years ago, most people believed that the institution of slavery could never be overcome. Large-scale social change is possible, and people such as ourselves are part of the process. In a very real sense, the choices we make about what kinds of products we buy, about what kind of cars we drive, about whether we recycle, and about the leaders for whom we vote all have an impact on future generations and on whether they will enjoy a sustainable world. To be sure, each of us will be challenged to make personal sacrifices. But as most parents will attest, there is joy and meaning to be found in making choices and sacrifices that protect the well being of one's children. Collectively, we are now in a position of choosing for humankind, for all creatures, and for all future generations.

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